

Physics and Control of “Afterglow” HCI-Beam Pulsewidths for Synchrotron and Atomic Physics Applications

M. NIIMURA, JPL; A. CHUTJIAN, JPL; A. GOTO, RIKEN; M. LAMOREUX, UNIV. P&M CURIE; S. SMITH, JPL; and Y. YANO, RIKEN

Synchrotron accelerators demand a short pulse (≤ 0.4 ms) of highly-charged ions (HCIs) at 1-10 Hz repetition frequency using the afterglow current of an ECR ion source (ECRIS) as the injector (LC program). Although the current may be smaller than that required for the LC/CERN (0.1-1 emA of Pb 27+ and 28+) the high-current pulsed beam is useful in atomic physics experiments. This paper presents the physics and technology to help control the afterglow pulsewidths: short pulsewidths have yet to be achieved, and long pulses ($>> 1$ ms) are sometimes required. The physics governing the complex time history of an afterglow pulse is controversial, but one can present evidence that interchange instability (ICI) takes place whenever a good, sharp pulse is produced. This is expected since the ICI mechanism successfully explained the low-frequency (1-2000 Hz) ion-beam oscillations beginning at low-pressure, high rf power operation of the ECRIS (i.e., a hot electron shell is produced whose stability depends on the density of cold background electrons and on the $M(\text{mass})/Q(\text{ion charge})$ of ions in the core [1]). If the ICI mechanism prevails, a smaller M/Q requires a lower rf power to produce a sharp pulse. To investigate this we have used an rf power pulser (capable of a 100% modulation depth for the main and second rf pulses), a diamagnetic loop, and an X-ray monitor. Tuning of the ECRIS to the optimal afterglow mode is tricky because the best afterglow mode should result when the cw mode is minimal, implying that the HCIs are well-trapped by the space-charge potential prior to trap disruption. We propose to optimize the integrated X-ray signal [2]. Also of interest, in experiments requiring pulsed operation, is the metastable content of HCIs produced in the cw and afterglow modes. Preliminary results at JPL indicate that low background gas density in the ECRIS (minimal metastable quenching) is the critical factor for optimal metastable production in either mode.

This work was carried out in part at JPL/Caltech, and supported through NASA.

[1] M. Niimura et al., Rev. Sci. Instr. 71, (2000) (in press)

[2] M. Lamoreux et al. 14th Int. Workshop on ECR Ion Sources (Geneva, 3-6 May 1999).